NATIONAL AIR DISASTER ALLIANCE / FOUNDATION

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MISSION: To raise the standard of safety, security, and survivability for aviation passengers, and to support victims' families.
NADA/F, a non-profit organization, with thousands of members worldwide, represents survivors, family members and aviation professionals from over 90 aviation disasters, as well as the traveling public.

Dissenting Opinion:
FAA ARAC Fuel Tank Inerting Harmonization Working Group (FTIHWG)

Submitted by James H. Hurd, FTIHWG Member, TWA 800, and
***NATIONAL AIR DISASTER ALLIANCE/FOUNDATION* Board Member.**
Submitted March 13, 2002 at the FAA Aviation Rulemaking Advisory Committee (ARAC) Executive Committee (ExComm) Meeting.
Subject to revisions as a result of additional information from the Working Group.

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Introduction

September 2000 an FAA Aviation Rulemaking Advisory Committee (ARAC) was formed in order to provide advice to the FAA about implementing fuel tank inerting (FTI) into center wing tanks (CWT). Their Final Report was issued in June 2001 and submitted to the FAA ARAC Executive Committee (ExComm) in August 2001. Clarifications were requested by the Committee and these will be submitted to the Committee in March 2002. **Both the report and the clarifications are found to be deficient as described in detail below.** It should be noted that this is a second effort to address the fuel tank explosibility issue.

In 1998 the FAA initiated an ARAC study regarding fuel tank inerting in the ullage (empty space with vapors) portion of center wing tanks (CWT). This study was a result of the TWA 800 crash and the National Transportation Safety Board (NTSB) recommendations. This study lasted approximately six months. The findings were that more studies and technology were required and that the cost benefit analysis was not within FAA guidelines.

An explosive mixture of fuel vapors and air will form in the ullage volume of aircraft fuel tanks. A subsequent presence of an active ignition source resulted in a damaging explosion such as the most recent known examples:

- a Boeing 737, Bangkok, Thailand, 2001;
- a Boeing 747, New York, New York, 1996; TWA 800, and
- a Boeing 737, Manila, Philippines, 1990.

Lowering the oxygen content in this ullage volume with nitrogen will prevent these explosions and increase flight safety. A mechanism, which absolutely eliminates the possibility of these fuel tank explosions, is to **reduce the oxygen concentration within the fuel tanks, by increasing the nitrogen content. *Any* ignition source is then ineffective**.

It should be noted that fuel tank inerting is supported by members of the National Transportation Safety Board (NTSB) and continues to be posted as one of their top ten "Most Wanted" safety improvements. On 8 August 2001, Carol Carmody, acting chair, expressed her disappointment that the FAA (FTIHWG) Working Group relied on cost benefit ratio (CBR) as a basis in recommending that fuel tank inerting not be implemented.

On 23 August 2000, the past NTSB chair, Jim Hall, noted that:

> *"It is imperative at long last, that the aviation community move with dispatch to remove flammable fuel/air mixtures from the fuel tanks of transport category aircraft **as recommended** to the FAA by the CAB **on 17 December 1963** as a result of the Pan Am flight 214 disaster."*

It is expected that the NTSB can provide to the FAA their information, which supports the inerting of fuel tanks.

The FAA has compiled a list of **27 incidents of fuel tank ignitions**, including fatal explosions from commercial and military flights. See Page 12 of this report for the compilation. It is possible that there are additional incidents or disasters that were not accurately investigated.

> Captain Tim Murphy reminded ALPA at its Safety Meeting in August 2001, *"Not all plane crashes are investigated, worldwide."*

Significant criticism of the concept of cost benefit analysis or ratio is justified, and quantitative data may be chosen which significantly affects these calculations. **It is possible to argue that an immediate program should be initiated in order to inert aircraft fuel tanks, and thus effectively eliminate this explosion danger.**

Cost/Benefit Analysis

The 1998 FTIHWG report stated a cost of \$5B to \$20B over a 15-year period, and the 2001 FTIHWG report stated a cost of \$20B to \$35B over a 15-year period, with no satisfactory explanation for the inconsistencies of their cost benefit analysis. *NADA/F* believes that technical research could demonstrate that lower costs can be achieved with all the scenarios.

- Based upon information available and discussed at the FTIHWG, a normalized charge (cost to the passenger) could be as low as \$.25 per passenger per flight delivered.
- Cost of nitrogen, which is 100% effective in preventing an ignition, could be a charge of \$8.25 for the nitrogen, plus a service charge of \$100 per aircraft per flight.

The basic concept of cost/benefit ratio (CBR) or cost/benefit analysis (CBA) seems to be fatally flawed. The numerical value can be made very large by having a large numerator or small denominator or very small by having a small numerator or large denominator. Having the quantity of the order of unity does not seem to resolve much. More often than not the financial quantities in the Working Group's report are at best estimates, or at worst sheer speculation. Also, some of the assumptions used to justify figures are flawed as explained below.

Within the June 2001 report there are numerous CBR calculations which give the results that the cost of nitrogen fuel tank inerting are greater than the benefits produced. For some of these calculations it is possible to make straightforward comments affecting their validity and/or changing the results to produce a more favorable situation for the implementation of nitrogen fuel tank inerting.

Comments on ARAC FTIHWG 2001 Final Report Dated 6/01/02

1. Pg. 1-7 ¶ 1.8 → Evaluation timeline assumes that it will take 36 months to certify a design and 84 additional months (7 years) to modify the fleet. Figure 1 is a rough cash flow diagram during the evaluation period. The non-recurring costs associated with inerting are realized between 2005 and 2015. Based on pg. 1-8 ¶ 1.8, there is only one expected accident that could be avoided in the 16-year evaluation period. This is due to the fact that no benefit could be realized before the system is implemented. It is suggested that the sensitivity analysis include an earlier implementation date, and/or a longer total time frame.

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Event	Reg Published			Design Cert							All go					
Cost	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
Benefit															↑	

Figure 1 – ROM Cash Flows of Cost and Benefit Over Study Period

2. A major assumption that the recently enacted SFAR 88 (Special Federal Aviation Regulation) would reduce accident rates by 75% is not supported by any evidence. Note that no source of ignition has been pinpointed for any of the three most recent explosions. To assume that 75% of these type of accidents can be avoided by inspecting just one of the possible sources is not credible. Further, it has been suggested that this type of manual inspection of wiring harnesses more likely would result in damage of brittle insulation and may increase the likelihood of accidents by creating ignition sources.

3. Page 1-8 2nd ¶ Indicates that only 1 airplane accident would be avoided in the 16-year study. Note that full inerting system capabilities would only be on line for 6 of those 16 years. *(See Page 12 for an FAA list of the 27 incidents of fuel tank ignition, including 13 during the last twenty years.)*

4. Page 1-8 4th ¶ Says 132 deaths avoided for GBI (Ground Based Inerting) and 253 for OBIGSS (Onboard Inert Gas generating System) over the 16-year evaluation period, which is 6 years of system functionality. The benefit over 16 years of operation would be 352 for GBI and 675 for OBIGGS.

5. Accident rates are based on only 3 data points, and therefore do not create a statistically significant pattern. Therefore these rates must represent a fairly low confidence interval. It is suggested that the sensitivity analysis include a range of accident rates that represent higher levels of confidence intervals.

6. Page 1-9 Figure 1-5. Again the benefit interval is only 6 years projected over a 16-year time frame the ratios vary from 14:1 to 20:1.

7. Page 2-2 ¶ 2.b → "Various means of supplying nitrogen (i.e., liquid. . .)" The report does not cover liquid nitrogen supplies. (Note that "i.e." stands for "that is", which indicates that they were to specifically look at liquid nitrogen).

8. Page 4-8 ¶ 4.5 → "it was estimated that 15% of avoided accidents would have otherwise occurred on the ground, the other 85% in flight. It was also assumed that 10% of the people would die in a ground explosion, while an in-flight explosion would be a complete loss. . ." These assumptions are not factually or statistically based. The sensitivity analysis should allow for large variation in these estimates. Refer to number 4 above. Over a 16-year period the lives saved are 352 for GBI and 675 for OBIGGS. If we allow that in 100% of explosions there is a total loss, then the numbers become 407 and 780.

	Benefit ($US billion)	Adjustment for 16 years of benefit	Adjustment for total loss	Cost ($US billion)	Cost-Benefit Ratio
GBI (HCWT only)	0.245	0.653	0.755	10.37	13.7:1
OBGI (HCWT only)	0.219	0.584	0.675	11.6	17.2:1
Hybrid OBIGGS (HCWT only)	0.257	0.685	0.792	9.9	12.5:1
OBIGGS (all tanks)	0.441	1.176	1.359	20.78	15.3:1

9. If we include the factors from item 8 in the sensitivity analysis, the most favorable scenarios become:

	Scenario from 8/8 Summary Pg#	Benefit ($US billion)	Adjustment for 16 years of benefit	Adjustment for total loss	Cost ($US billion)	Cost-Benefit Ratio
GBI (HCWT only)	37	0.281	0.749	0.866	4.196	4.8:1
Hybrid OBIGGS (HCWT only)	43	0.3	0.800	0.925	3.68	4.0:1

10. Page 6-14 → Inclusion of Capital costs may be redundant. It is likely that the operator of the system will absorb those costs, and recoup them via operating costs.

11. Page 11-1 Is the "willingness to pay" value of human life escalated in the out years? If not, then there is another skew in the data. The "willingness to pay" benefit is discounted back to 2005 at 7%. If no escalation was assumed, then the benefits are understated by that 7% discount. Since most of the benefits are in the out years, there is a significant impact. If the adjustments for escalation of benefit are included that changes the most favorable scenario.

12. A major domestic airline disclosed that the actual costs used by the airlines to account for loss of life vary between $2.7M and $4.0M based upon the demographics of the airlines route structure.

13. Page G-2, last sentence before Section 2.0 → States "See section 4 for more information about benefits." No section 4 is included in this report. Please provide missing or removed information.

Numerous examples may be cited of improvements being made within society to increase safety without performing a CBR analysis.

(a) In the Our Lady of Angels, Chicago IL, 1958 school fire resulting in 97 dead, an immediate sprinkler and call box installation was initiated and completed within two years for *all* Chicago schools.

(b) More recently, for the past several years Ford Explorer automotive rollovers, presumably initiated by defective tires, have resulted in over 200 deaths. An expenditure of approximately $4B has been made by only two corporations as a result of the initial recalls to correct this problem and a second recall valued at $41.5M has also most recently occurred.

(c) The Ford Motor Company also has an additional problem and is spending nearly $3B to replace millions of flawed ignition modules. These faulty systems resulted in 11 deaths and 31 injuries.

(d) Additionally, at present there is a massive recall of faulty fire sprinkler heads produced by one manufacturer, Central Sprinkler: the Omega model for residential use, and the GB model for commercial use. It has not been noted that a CBR has been done in order to justify the recall.

In an inverse situation a CBR was calculated by General Motors regarding the safety of fuel systems in automobile crashes. In a recent California jury trial verdict enormous damages, nearly $4B, were awarded to the injured as General Motors had reportedly decided that the $8 cost per vehicle required for fuel system redesign and manufacture was not cost effective compared to damages which would be awarded in any subsequent trials.

Finally, the U.S. Supreme Court has in the last term spoke on the issue of CBR. They judged unanimously in an U.S. EPA (Environmental Protection Agency) related case that only public health (substitute the closely related word safety) could be considered and not cost regarding new clean air standards.

Benefit Analysis

As currently structured the benefits chiefly accrue from the figure of $2.7M which is described by the DOT (Department of Transportation) as the amount *"which U.S. society is willing to spend on increased safety in order to prevent a death."* It should be stressed that the *NATIONAL AIR DISASTER ALLIANCE/FOUNDATION* does not agree with the DOT economists who have defined $2.7M as the cost of a life lost in an air crash, or the maximum amount of *"willingness to pay"* for aviation safety and security. History has shown that the American people have *NOT* found this an acceptable amount.

The current very adverse response by the thousands of families suffering from the loss of family members due to the events of September 11th, 2001, and to the provisions of the "Air Transportation Safety and Systems Stabilization Act," also indicate that this is a very inadequate amount.

Page 4, #8, of this document, references Page 4-8 ¶ 4.5 of the FTIHWG 2001 Final Report:
"it was estimated that 15% of avoided accidents would have otherwise occurred on the ground, the other 85% in-flight. It was also assumed that 10% of the people would die in a ground explosion, while an in-flight explosion would be a complete loss. . ."

This statement indicates that 90% of the passengers in a ground explosion would be survivors, and potential burn victims. The September 11th burn victims, helped by medical technology of 2002, will have medical bills greatly in excess of $2.7M per person, plus personal care, compensation for their pain and suffering, and have special needs that we cannot imagine. Indeed, juries and judicial rulings and settlements for air crash survivors, especially burn victims, have been ten times greater than $2.7M and more. No one would trade places with them for any amount of money, and society wants these victims compensated so that they receive the full support that they need. Industry should be willing to finance higher costs to prevent on board fires and explosions. When the money and technology are there, and have been there for 30 years, the industry should do everything possible to prevent fire and explosions on airplanes.

During a meeting between FAA rulemaking authorities and *NATIONAL AIR DISASTER ALLIANCE/FOUNDATION* members on 28 September 2001, it was indicated by the FAA that this benefit restriction was too limited and that the concept of benefits should be expanded. Such additional benefits should consider the costs of family breakups, which invariably results when a family member is lost. The U.S. government indicates that it has great respect and support for the concept of a small business. A political and legal environment is developed for such to thrive. The family is an ideal example of a small business, and post-air crash conditions should be favorable for the survival of this business.

As the events of September 11th have shown, and as will be applicable to other crashes, air disasters can have other enormous secondary economic effects which need to enter into the benefits calculations. There is the loss of passenger revenue due to fleet grounding and the reluctance of individuals to travel by air. The airlines first response is to lower fares (and profits) when passenger traffic decreases and people do not want to fly. There is decreased use of hotels, restaurants, rental cars, theaters, and all other items related to travel. There may be extensive property loss as a result of an air crash as well as an extensive loss of jobs.

Some quantitative data may be connected to the four airplane crashes on September 11th, which show that the benefits of increased safety have been significantly underestimated in the past.

- $2T Stock market losses may be estimated (from Milken Review)
- $15B in air transport losses, or more, **and still growing**
- $90B for property losses and interrupted business at the Pentagon and New York City (NYC) (per Swiss Reinsurance Co.) OR
- $105B NYC losses estimated through June 2003 for lost revenue, damage and rebuilding (source NYC Comptroller, and Congressional aids)
- $30B for the first five months of the War on Terror abroad (recent news)
- $140B Projected Federal Stimulus Package to prop up the U.S. economy (not including global losses) ("Newsweek," 10/1/01).
- 32 Boeing airplanes for which struggling airlines might not be able to take delivery ("Wall St Journal" 10/9/01)
- $0 Financial compensation for some airline executives. Pay cuts and job insecurity industry-wide.
- 1.8M jobs lost in the U.S. by the end of 2002, all as a result of the September 11th aviation disasters.
- No cost estimates for an aviation disaster at a nuclear power facility (Milken Review)

At present, the job loss in the aviation industry alone worldwide stands at 400,000, including an estimated 30,000 job loss for Boeing alone. The cost of the TWA 800 crash is currently estimated to be approximately $1B. The cost of Swissair 111 is estimated at possibly $2B, and the airline is no longer in business. The Libyan government has reportedly offered a $6B settlement with regard to PanAm 103, plus the costs of damages since 1988, and the airline failed to stay in business. A potential casualty of unknown magnitude is the collapse of the insurance and reinsurance market as a result of the aviation disaster losses.

The airline industry is at crisis worldwide, and much needs to be done to re-build faith in the industry. *NADA/F* urges government and the industry to evaluate safety and security recommendations first on their merits to re-build confidence in the aviation industry. The

American people are not accepting known fatal flaws and safety and security contracted to the lowest cost bidder.

At the 28 September 01 meeting at the FAA with *NADA/F*, the economist stated that he had not imagined multiple accidents in a single day. We cannot afford for the industry to ignore that possibility ever again.

As a result of the next such aviation disaster punitive damages of unknown amounts may be awarded to families suffering the loss of members. On 17 August 01, $400+M in damages were awarded against Cessna Aircraft Co. regarding an alleged known defect concerning the failure of seat positioning locks.

The information above would indicate that the dollar amount attributed to benefits could and should be increased significantly, thus substantially decreasing the figure for the CBR.

The June 2001 ARAC Final Report does put the air transport industry on notice that there is a known single point failure mechanism which will produce a catastrophic fuel tank explosion. The report also indicates that the nitrogen inerting of fuel tank ullage is 100% effective in eliminating fuel vapor/air explosions within aircraft fuel tanks. A known hazardous condition may be eliminated.

In other scenarios, where nitrogen-generating systems are considered, the small amount of information which is available in the unclassified world would seem to indicate that current military technology, if available for use, could also lower the cost estimates. The military has been using fuel tank inerting for over 30 years, and their classified information could be helpful.

<u>Ignition Source Control</u>

Benefits Attributed to SFAR 88 (Special Federal Aviation Regulation)

The FTIHWG determined that the benefit of ullage inerting should be reduced to reflect the benefits offered by new procedures defined by SFAR 88. The SFAR was released as the Working Group was assessing the benefits of inerting, and these benefits were discounted considerably (75%) based on the assumption that the process defined in the SFAR would yield significant benefits.

"The 75% reduction had been estimated by the 1998 FTIHWG." ***[FTIHWG Final Report*** **Pg. H-9]**

The benefits offered by SFAR 88 are difficult to quantify, because many of the ignition sources for fuel tank explosions have not been identified as noted by the FAA [**Federal Register May 7, 2001 pg. 23127**]

"As noted, the FAA has not quantified the potential benefits from this final rule because there is uncertainty about the actual ignition sources in the two fuel tanks..."

Further the regulatory text in **SFAR 88** calls for reducing the exposure to flammable mixtures. From **§25.981(c):**

"The fuel tank installation must include either--

1. Means to minimize the development of flammable vapors in the fuel tanks (in the context of this rule, "minimize" means to incorporate practicable design methods to reduce the likelihood of flammable vapors); or
2. Means to mitigate the effects of an ignition of fuel vapors within fuel tanks such that no damage caused by an ignition will prevent continued safe flight and landing."

The FTIHWG assumed a 75% reduction in fuel tank explosions resulting from the implementation of SFAR 88, however, has this included the reduction of flammability exposure specified in the regulatory text for SFAR 88?

A **fuel/air explosion** (FAE) occurs when five items come together:

- fuel,
- oxidizer (oxygen),
- ignition source,
- confinement, and
- vapor phase fuel/oxidizer mixing.

The first three are commonly known as the fire triangle while all are known as the explosion pentagon. For the latter situation the removal of any one item precludes an explosion, but the attempted control of only one component, such as ignition sources, is a risky strategy. It may decrease the number of incidents, but it will not eliminate them. Experiences in other industries such as the process, coal mining, and grain and feed have shown that it is necessary also to control the fuel in order to eliminate fuel/air explosions.

It is exceedingly difficult to have two failures at the same time — ignition sources and combustible fuel/air mixture. Such a strategy was adopted by another segment of the transportation industry, maritime petroleum shipping, where the scrubbing of tankage led to an electrostatic ignition source for the fuel vapor/air mixtures. An analysis of the problem led to the use of stack gases as an oxidizer diluent within the empty tanks.

Nonconventional ignition sources have become of increased concern.

- Silver components within the fuel tank through chemical reactions occurring in the presence of low sulfur fuel can produce conducting paths leading to short circuits.

- On 26 November 1989 an Avianca B-727-100 crashed shortly after takeoff from Bogota, Columbia as a result of the detonation of an explosive device placed in a seat on the starboard side of the passenger cabin, which in turn ignited fuel vapors in an empty fuel tank.

- On 22 December 2001, an American Airlines 767-300, Flight 63, traveling from Paris, France to Miami FL, was diverted to Boston MA. A passenger sitting in a port side window seat slightly aft of the wing trailing edge had attempted to detonate an explosive device which had been hidden in his shoes. Had the initiation attempt been successful and had he been located above the center wing tank he may have ignited, with fatal results, the fuel vapors in the center wing tank.

- January 1995 responding to a routine fire alarm in a Manila apartment building, firemen and investigators uncovered a bomb-making factory with electronic timers and terrorist plans regarding near-future transpacific flights. The timers matched those used to explode a bomb on a Philippines airline flight of a few weeks earlier, which killed one passenger and forced an emergency landing. The eleven long haul flights, all with intermediate stops on a single day, designated as imminent targets involved mainly those of United and American Airlines, the same airlines targeted for September 11th. The explosive technique of operation Bojinka of placing a small bomb within the cabin certainly could have been enhanced by locating it over the center wing tank and detonating it later into the flight when its liquid fuel had mostly been consumed.

As with the case of the Avianca and American Airlines flights, SFAR88 would not have decreased the likelihood of these intentional ignition sources.

In the process, coal mining, and grain and feed industries unanticipated/unexpected ignition sources led to the failure to eliminate explosions by the control of ignition sources exclusively. It will be the same situation regarding SFAR88. It is thus impossible to definitively quantize its effect and not to implement a second backup strategy such as nitrogen fuel tank inerting.

Related Safety Issues

It is not realistic to try to inert the fuel tanks in all aircraft at all locations within the global aviation network at the same time. A risk and consequence analysis needs to be performed relating to the different types of aircraft so as to propose an intelligent implementation of an inerting program.

Logic would dictate that one would begin with the high risk, heated center wing tank (HWCT) aircraft currently in production or to be put into production. Those to be neglected would be ones of smaller capacity near the end of their airframe life. Geographically, the initiation would occur at airports with the largest passenger traffic and last implementation would be those with little passenger traffic.

Any **cost associated with the implementation of fuel tank nitrogen inerting** must be normalized in a rational fashion. This is not an enormous one-time expense which will be paid for by the air transport industry. Just like any other expense it will be passed on to the passengers.

1. Based upon information available to and discussed by the Working Group, such a normalized charge could be as low as $0.25 per passenger per flight delivered.
2. There could be a charge of $8.25 for the nitrogen plus a service charge of approximately $100 per aircraft per flight.

- Even now, when fuel prices are at an all time low, the airlines are authorized to charge a fuel surcharge for each ticket of $18.60 one way, and $37.20 round trip. The surcharge was added when the price of Jet A fuel was at a maximum, and may still be charged to the customer.
- Passenger Facility Charges (PFC's) can be a maximum of $4 (plus tax) per airport, with a maximum of $20 (plus tax) per ticket, and the PFC's continue to increase.
- The domestic transportation tax is 7.5% per ticket, and billions have accumulated in the federal Aviation Trust Fund.
- The new security tax is $2.50 one way and $5 round trip, or with multiple segments can be $10 round trip per ticket.
- The International Transportation Tax used to be $3 per round trip ticket, and now round trip international taxes can be $200+ per ticket. International ticket taxes continue to increase in the number of taxes, and the amount of the tax, or service charge, or user fee.

Such an expense of $.25 per passenger per flight, or $100+ for nitrogen, per airplane, per flight is literally peanuts in comparison to the cost of the ticket, taxes, and service charges. Since September 11th passengers have not complained about the security tax, and have expressed that they are willing to pay for higher levels of safety and security.

Conclusions

The combustible fuel vapor and air mixture which appears in the ullage of HCWT's (heated center wing tanks) during a certain period of flight time, 33%, represents a safety risk. Nitrogen inerting eliminates this risk for a very minimal cost. The modification of the air transport system to implement this procedure may be done in a very intelligent, controlled manner. As the events of September 11th have shown, air crashes have many unforeseen consequences, and the air travel system has shown itself to have limited elasticity. The next HCWT explosion may well have extensive foreseen and unforeseen consequences. **A measured, determined introduction of the nitrogen fuel tank inerting technology is imperative beginning immediately in order to enhance aviation safety.**

The following is the FAA compiled list of incidents of fuel tank ignitions from the Federal Register: April 3, 1997 (volume 62, Number 64) Page 16013-16041

www.epa.gov/fedrgstr/EPA-GENERAL/1997/April/Day-03/g8495.htm

Commercial Fuel Tank Explosions:

	Model	Operator/Location	Year	Fatal	Hull loss
1	B707	OSO	1959	4	Yes
2	B707	Elkton	1963	81	Yes
3	B707	San Francisco	1965	0	Yes
4	B727	Southern Air Transport, Taiwan	1964	1	No
5	B727	Minneapolis	1968	0	No
6	B727	Minneapolis	1971	0	No
7	DC-8	Toronto Canada	July 1970	106	Yes
8	DC-8	Travis AFB	1974	1	Yes
9	DC-9	Air Canada	1982	0	Yes
10	Beechjet 400	Jackson MS	June 1989	0	No
11	B727	Avianca	1989	107	Yes
12	B737	Philippine Airlines	1990	8	Yes
13	B747	TWA 800	July 1996	230	Yes
14	B737	Thai Airlines	2001	1	Yes

Military Non-Combat Fuel Tank Explosions:

1	B52	Loring AFB Maine	July 1970	0	Yes
2	B707	USAF Spain	June 1971	Yes	Yes
3	B52H	Minor ND AFB	Nov. 1975	0	Yes
4	B747	Iranian Fuel Tanker	1976	7	Yes
5	KC135Q	Plattsburg AFB NY	Feb. 1980	Not Noted	Yes
6	B52G	Robins AFB Georgia	Aug. 1980	Yes	Yes
7	KC135A	Near Chicago	March 1982	Yes	Yes
8	B52G	Grand Forks AFB ND	Jan. 1983	Not Noted	Yes
9	KC135A	Altus AFB OK	Feb. 1987	Yes	Yes
10	B52H	Swayer AFB MI	Dec. 1988	Yes	Yes
11	KC135A	Loring AFB Maine	Sept. 1989	Yes	Yes
12	KC135A	Loring AFB Maine	Oct. 1989	Yes	Yes
13	KC135R	Mitchell Field, Milwaukee WI	Dec. 1993	Yes	Yes

Total 27

Updated: March 11, 2002

Glossary

Basic Inerting design systems:

GBI **Ground Based Inerting** – A system using ground-based nitrogen gas supply equipment to inert fuel tanks that are located near significant hear sources or that do not cool at a rate equivalent to unheated wing tanks. The affected fuel tanks would be inerted once the airplane reaches the gate and is on the ground between flights.

OBGI **Onboard Ground-Inerting** – An onboard system that uses nitrogen gas generating equipment to inert fuel tanks that are located near significant heat sources or that do not cool at a rate equivalent to an unheated wing tank. The affected fuel tanks will be inerted while the airplane is on the ground between flights.

OBIGGS **Onboard Inert Gas Generating System** – A system that uses onboard nitrogen gas generating equipment to inert all the fuel system's tanks so that they remain inert throughout normal ground and typical flight operations.

Derivative combinations of OBGI and OBIGGS were also studies, and were described as **"hybrid systems."**

ARAC Aviation Rulemaking Advisory Committees

CBA Cost Benefit Analysis

CBR Cost Benefit Ratios

FTIHWG Fuel Tank Inerting Harmonization Working Group

SFAR Special Federal Aviation Regulation